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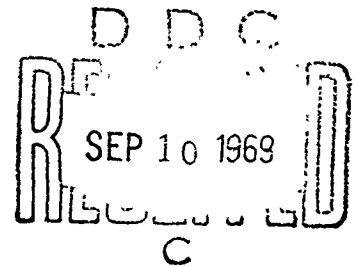
Research and Development Technical Report
ECOM-3142

AN/VRC-12 CABLE EVALUATION

by

Frank DeNucci

July 1969



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TECHNICAL REPORT ECOM-3142

AN/VRC-12 CABLE EVALUATION

by

Frank DeNucci

**Electronic Parts and Materials Division
Electronic Components Laboratory**

July 1969

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US ARMY ELECTRONICS COMMAND, FORT MONMOUTH, N. J.

ABSTRACT

This study was initiated to investigate the cause of various reports of field failures of wires and cables (multi-conductor), specifically cables which are part of the AN/VRC-12 Radio Equipment.

Various types of cables, fabricated per MIL-C-3432 and similar to those reported as having failed in tactical use, were tested.

A description of each type is provided in this report along with detailed physical test data, such as tensile and elongation of conductor insulating material (aged and unaged) and mechanical tests on the cable such as, flex, impact and twist.

None of the cables tested exhibited outstanding performance in all the mechanical tests. When cables did perform very well with regard to one or two tests, they did poorly in others. All cables exhibited variations of performance and practically no correlation was obtained between the mechanical tests and the physical characteristics of the insulation.

Performance tests however, do offer some control on the construction and manufacturing variables of the cable. New design considerations are recommended based upon the evaluation. Requirements for the physical properties of the insulation are also recommended to upgrade the material and provide greater stability with respect to accelerated temperature aging. Mechanical performance tests on finished cable are recommended to provide an overall control on the constructional quality of the finished cable.

These tests will be incorporated in Military Specification MIL-C-3432 along with appropriate changes in Government inspection procedures to insure improved reliability of multi-conductor cables.

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BACKGROUND

A directive from the office of Project Manager, Selected Tactical Radios, U. S. Army Electronics Command, was forwarded to this laboratory,* stating that there exists a continuous major problem with respect to failures in wire and cable, specifically cables which are part of the AN/VRC-12 Radio Equipment. The directive stated that cable specifications are not compatible with user requirements and recommended that the entire field of wires, cables, and cable assemblies be reviewed and revised.

A meeting was arranged with representatives of the Components and Materials Division of Procurement & Production Directorate to determine: (1) What types of tactical cables were failing; (2) What types of cables were in large quantity procurement; and (3) Into what specific equipments these cables were being used. The information gained at this meeting, summed up briefly was: (1) Most cables were procured per Specification MIL-C-3432, and (2) The only known failure occurred with cables used on the AN/VRC-12 equipment.

To further investigate the Project Manager's request, a meeting was held with a representative of the Project Manager's Office to discuss cable failures in the field and to determine the type of cables failing and the cause. The items discussed were: (1) Early history of numerous failures (as much as 50 percent) of cable assemblies when Radio Equipment AN/VRC-12 was implemented in the field in October 1963 and (2) The need for more rigid specification requirements.

A meeting was arranged at Frankford Arsenal to discuss cable testing techniques, and cable testing equipment relative to multi-conductor cables and to obtain procurement information for a Frankford Arsenal Cable Testing Machine.

Tobyhanna Military Supply Depot was also queried to determine the type of cables failing and what cables were in large quantity procurement. The inquiry revealed numerous failures of cable assemblies used with AN/VRC-12 equipments. Tobyhanna reported 25,000 feet of cable as "dry-rot" cable and 20,000 cable assemblies with such defective cable.

EVALUATION PROGRAM

1. Cable Sample Description

Two cable samples made per Specification MIL-C-3432 were obtained from Components & Materials Division, Procurement and

*Electronic Components Laboratory

Production Directorate, and consisted of types CO-18LOF (14/22, 4/22 SI) 0500 made by the Cornish Wire Company, and CO-12LOF (12/22) 0325 made by the American Insulated Wire Company. Due to the short lengths of these samples, a complete series of tests could not be made so additional cable samples of various manufacturers were requested from Tobyhanna Supply Depot. The samples received and tested were types CO-18LOF (14/22, 4/22 SI) 0500, CO-09LOF (7/22, 2/22 SI) 0325 made by the American Insulated Wire Company, and CO-12LOF (12/22) 0325 marked Industrial Components Company (made by American Insulated Wire Company). Other cable samples were obtained from Tobyhanna which were marked "dry-rot". In order to properly evaluate cables representative of various companies'

to design and cabling techniques, a procurement was made directly to three cable manufacturers. Only one each cable type CO-18LOF (14/22, 4/22 SI) 0500, and CO-12LOF (12/22) 0325 from American Insulated Wire Company and CO-09LOF (7/22, 2/22SI)0325 from ITT Surprenant was received.

2. Test Procedures

A testing and evaluation program was immediately initiated on multi-conductor, shielded, and unshielded cables. These cables, fabricated per MIL-C-3432, were similar to the cables used with AN/VRC-12 equipment which were reported as having failed in tactical use.

Cable samples were subjected to flex, impact, and twist tests in accordance with Specification MIL-C-13777. These tests were designed, with some modification of the flex tests, to simulate field use and abuse and were performed on a Frankford Arsenal Cable Testing Machine.

The flex tests consisted of placing the cable samples between two half-inch mandrels, with the lower end of the samples fixed approximately twelve inches below the mandrels (instead of weights) to confine the flex or bend over the mandrels instead of allowing the cable sample to ride up and down over the mandrels. Cable sample length differences between cable in the vertical and horizontal position and adjustment of a ten-pound tension on the cable samples were accomplished by attaching a spring between the samples and the oscillating arm of the machine. The oscillating arm of the machine flexed the cable samples alternately over each mandrel. Starting from zero (horizontal position) and rotating through a 180 degree arc of the flexing arm and back 180 degrees to zero position constituted one cycle. This modification to the MIL-C-13777 test method was made to provide a more realistic test of the cables. The method simulates sharp bending of the cable at the back end of a connector where the cable gets the

most bending abuse when it is used on an assembly and installed in equipments.

Impact tests consisted of allowing a weighted hammer to strike the cable sample which was clamped over an anvil. The weight size and height of the hammer was in accordance with MIL-C-13777 except for the types CO-12LOF (12/22) 0325 and CO-09LOF (7/22, 2/22 SI) 0325 cables. The drop height of the hammer was reduced because of the severity of the test on these smaller diameter cables which had thinner wall jackets compared to the 18-conductor cables.

Twist tests consisted of attaching one end of a cable sample to a mechanism that allowed the cable to ride up and down over a pulley. The opposite end of the cable sample was attached to a weight that applied tension and a 45 degree (each side of zero) twist to the cable.

3. Instrumentation

Cable samples for the tests were prepared by connecting the conductors in series and then terminating into a control box. Since the cable testing machine was located a considerable distance away and to eliminate constant monitoring of the flex and twist tests which were of long duration, a control box (Fig. 1) was designed and fabricated to automatically stop the cable testing machine and the cycle counter when the cable sample failed. Twenty-four volts D-C were applied through a rheostat and relay to the cable conductors, which were connected in series. The circuitry (Fig. 2) has a reset switch which closes the circuit, energizes the relay and starts the cable testing machine. Discontinuity in the cable conductors opens the circuit and stops the cable testing machine. Relay drop-out sensitivity is controlled by the "Load-Adj" rheostat.

Impact tests were controlled by a Short-Open Indicator (Fig. 3). A 110V A-C potential was applied to the conductors of the cable sample through an adjustable load to indicate 0.5 ampere. Indication on the ammeter permitted determination of failure caused by broken conductors or by short circuits between conductors. Failure due to either cause terminated the test. The electrical circuitry (Fig. 4) consisted of connecting a rheostat, ammeter, resistors (at each end of the conductors), and cable conductors all in series. Resistor values of 10 ohms were used for a cable having 18 conductors (17 resistors) to permit adjusting the control rheostat resistance in the circuit to 0.5 A.; also, to allow cables having as few as 9 conductors to be used with this indicator as there was sufficient regulation with the rheostat to adjust the load to 0.5 ampere. Small two-watt resistors were used to restrict the size of the resistor boxes. The on-off switch was

a momentary type so that the circuit was closed for the short time duration necessary to read the meter at each hammer impact upon the cable sample and to prevent the resistors from overheating.

RESULTS

The results of the tests are summarized in Table 1 and detailed data are tabulated in Tables A1 - A4 of the Appendix. Cornish Wire samples (Table A1) exhibited relatively high impact life, the best of all cables tested. This was attributed possibly to the addition of a textile braid over the individually insulated conductors. The braid tended to cushion the conductors from each other when the cable was subjected to impact. Although advantageous for impact, the braid tends to be a disadvantage in flexing and twisting of the cable. The textile braid restricts the insulated conductors from sliding back and forth within the cable jacket during flex and twist, possibly putting extra stress on the copper conductors. AIW 1964 cable samples (Table A2) showed relatively low impact and twist life; AIW 1963 "Dry Rot" cable samples (Table A2) showed low flex life and the poorest impact resistance of all the samples, although twist life was relatively high. Again, this may be attributed to the textile core wrap, having a similar reaction among the conductors within the cable as the textile braid over the individually insulated conductors. AIW 1966 samples (Table A2) exhibited relatively high flex, impact and twist life as compared to 1963 and 1964 samples. This was possibly due to the Mylar tape core wrap which allowed the conductors more freedom of movement during the twist test and absorbed, to some extent, the hammer blows during the impact test. Cables, type CO-12LOF (12/22) 0325 marked "Industrial Components Company" (made by AIW 1965) and AIW 1965 (Table A3) exhibited high twist life, relatively high flex life, but relatively poor impact. These cables contained no individually shielded conductors, hence there was no restriction or abrasion from shields on adjacent conductors during twist tests which would put undue stress on the copper conductors. These cables averaged relatively the same life cycles for each of the flex, impact and twist tests.

Cables, type CO-09LOF (7/22 - 2/22 SI) 0325 manufactured by ITT Surprenant (Table A4), showed relatively high impact life as compared to AIW cables. This was possibly due to the textile reinforced jacket affording some protection to the conductors by absorbing the shock from the hammer blows during the impact tests. The flex and twist life of these cables were comparable; however, the flex life is considered poor.

In order to determine if the conductor material was at fault for the low twist life of the AIW 1964 samples and the low flex life of the AIW 1963

samples labeled "dry-rot", tensile and elongation tests were performed on the copper conductors (Table 2). The tests and results were based upon requirements and values of Federal Specification QQ-W-343. The stranded #22 AWG conductor was used for these tests. Strands were not removed from the conductor because tensile strength values are not specified in the specification for this strand wire size (#34 AWG). The elongation of copper conductors for the AIW 1963 samples (labeled "A and B") and the AIW 1964 samples (labeled "From 19 and 28 cycle twist) were less than the (15% after stranding) minimum requirements of QQ-W-343. Cornish samples met the elongation requirements. All the AIW 1964, AIW 1963, and Cornish samples met the tensile requirements.

Military Specification MIL-I-3930 specifies a minimum tensile of 450 psi and 200 per cent elongation for unaged conductor insulation for wall thickness between 6 to 20 mils. For insulation walls over 20 mils, the tensile and elongation minimum requirements are 600 psi and 250 per cent respectively. Shielded conductors of the AIW 1963, 1964 and 1966 samples were tested because heat retention in the shields when the cable jacket is applied could possibly cause degradation of the shielded conductor insulation. No testing was made of the shielded conductors of the Cornish Wire samples due to insufficient cable.

Insulation elongation (unaged) values for samples of AIW 1963, and AIW 1964 (Table 3) were borderline specification values, wherein the tensile values were above specification requirements. Other cable samples passed specification requirements for tensile and elongation. AIW 1966 samples were well above the minimum requirements for both tensile and elongation.

Tensile and elongation tests were also made on insulation after air-oven conditioning for 168 hours at 100°C to possibly duplicate "dry-rot" due to overcuring. The results of these tests are also shown in Table 3. AIW 1966 samples procured directly from the manufacturer were also subjected to air-oven aging for 1/2 hour at 345°F (simulating jacket extrusion temperatures) in order to possibly duplicate "dry-rot" due to overcuring during jacket extrusion. Similar samples were subjected to air-oven aging for 1/2 hour at 400°F (also simulating possible temperature jacket extrusion) again to duplicate insulation dry-rot (Table 3).

None of these air-oven aging tests duplicated the "dry-rot" insulation (i.e., degradation to the degree that the insulation lost all its elastomeric properties and the material cracked or crumbled with no tensile load). The insulation did crumble at elongations under very small tensile stress, see Fig. 5 and 6. However, later tests of air-oven aging of insulated conductors (including an experimental cable with ethylene-propylene rubber insulation)

at 100°C did result in significant deterioration after two weeks, and duplicated insulation dry rot after three weeks (See Fig. 7 and Table 3).

The repetition rate of conductor failures shown in Table 4 was not intended to indicate conductor failures due to different manufacturers or time of manufacture but rather to locate or isolate the number of failures which occurred for each conductor in respect to other conductors included in the cable. For instance, for cable type CO-18LOF(14/22 - 4/22 SI) 0500 a total of nine conductor failures were recorded for the black/white conductor and three failures for the adjacent conductor blue/black. Almost all conductors failed at least once on the impact tests. The three failures for the conductors color-coded blue, and white/black could be due to the fact that they were adjacent to the shielded conductors, and the impact hammer could possibly have driven the broken shield strands into these insulated conductors.

No pattern is discernible for the failures of conductors for the CO-12 LOF (12/22) 0325 type cables. The conductor failures resulting from flex, impact and twist tests were of relatively the same life cycle. This cable contains no shielded conductors, hence, no interaction due to conductor shields and adjacent insulated conductors. Conductor failures shown for cables, type CO-09LOF (7/22 - 2/22 SI) 0325 (Table 4) indicate a high failure rate of the white and black conductors. However, only two of the three failures were recorded for the AIW 1965 cable of the respective conductors and three and two failures for the ITT cable of the same conductors. More cable tests should be made to arrive at further conclusions.

CONCLUSIONS

Three cable types used with AN/VRC-12 were evaluated for conformance to Specification MIL-C-3432 and for performance on mechanical tests of flex, twist, and impact per MIL-C-13777. The data was analyzed to determine causes of failure and necessary revisions in specification requirements to provide greater reliability. Primary effort was directed to CO-18LOF (14/22 - 4/22 SI) 0500 because of its complexity and its failure in the field. The pertinent results of the evaluation are as follows:

1. Cable samples labeled "dry rot" did not reveal a disintegrated insulation but rather a poor grade of insulation when tested for tensile and elongation per MIL-I-3930.
2. Although the insulating material (SBR) exhibited physical characteristics after one week at 100°C greater than the initial values of MIL-I-3930,

it deteriorated rapidly after one week at 100°C and began to disintegrate at approximately three weeks at 100°C. The insulation also met requirements for tensile and elongation after 1/2 hour at 400°F, but it decreased approximately 30% in tensile from the unaged samples. The aging condition did not simulate "dry-rot".

3. EPR insulation was highly stable at 100°C, and exhibited virtually no change in physical properties for the period tested.

4. No influencing factor was apparent in determining the flex life of the cables tested other than the fatigue of the copper conductors. All failures were due to breaks in the conductors with the insulation intact.

5. None of the cables exhibited outstanding performance in all of the mechanical tests. When cables did perform very well with regard to one or two tests, they did poorly in the others. The Cornish Cable, however, was not outstanding in any one test but exceeded the requirements for all tests, and was superior to the other cables in regard to impact. The insulation in the Cornish cable also had good initial physical properties.

6. Although there were variations of performance and no established correlation between the mechanical tests and the physical characteristics of the insulation, performance tests do offer some control on the constructional and manufacturing variables of the cable.

7. The use of braided coverings over the insulation, and plastic tape wraps contributed to the outstanding performance of some of the cables in at least one of the mechanical tests.

RECOMMENDATIONS

1. The requirements of the physical properties of insulation per MIL-I-3930 should be upgraded to provide greater stability with respect to accelerated temperature aging. These upgraded requirements will improve the overall performance of cables per MIL-C-3432. Marker threads indicating month and year of manufacture should be provided under each conductor insulation to insure that conductors^{*} are not excessively aged in storage prior to cable fabrication.

2. Mylar tape wraps should be used over and under the metallic braid of shielded conductors to prevent abrasion damage and piercing of insulation by broken strands. In multilayer cable construction the shielded

^{*}with insulation

conductors should be in the inside layers to minimize their vulnerability to damage. The center of the cable core should be occupied by filler material rather than a conductor to eliminate excessive stresses on such a conductor.

3. Despite the variability in test results, and the evaluation limited to light duty cables, mechanical performance tests on finished cables provide an overall control on the quality of the cable with respect to numerous constructional details. The test procedures for flex, twist, and impact per MIL-C-13777 should also be incorporated into MIL-C-3432 with the following minimum requirements: 1500 flex cycles, 1500 twist cycles, and 50 impacts.

4. Appropriate changes should be made in the inspection test procedures to incorporate the accelerated temperature aging of insulation and the mechanical performance tests to assure improved reliability of the finished cable to be delivered to prime contractors.

Implementation of the specification revisions will be undertaken by the Electronic Components Laboratory of this Command in coordination with the Procurement & Production Directorate. However, the procurement agency must exercise adequate inspection surveillance to achieve the benefits of the upgraded specification requirements.

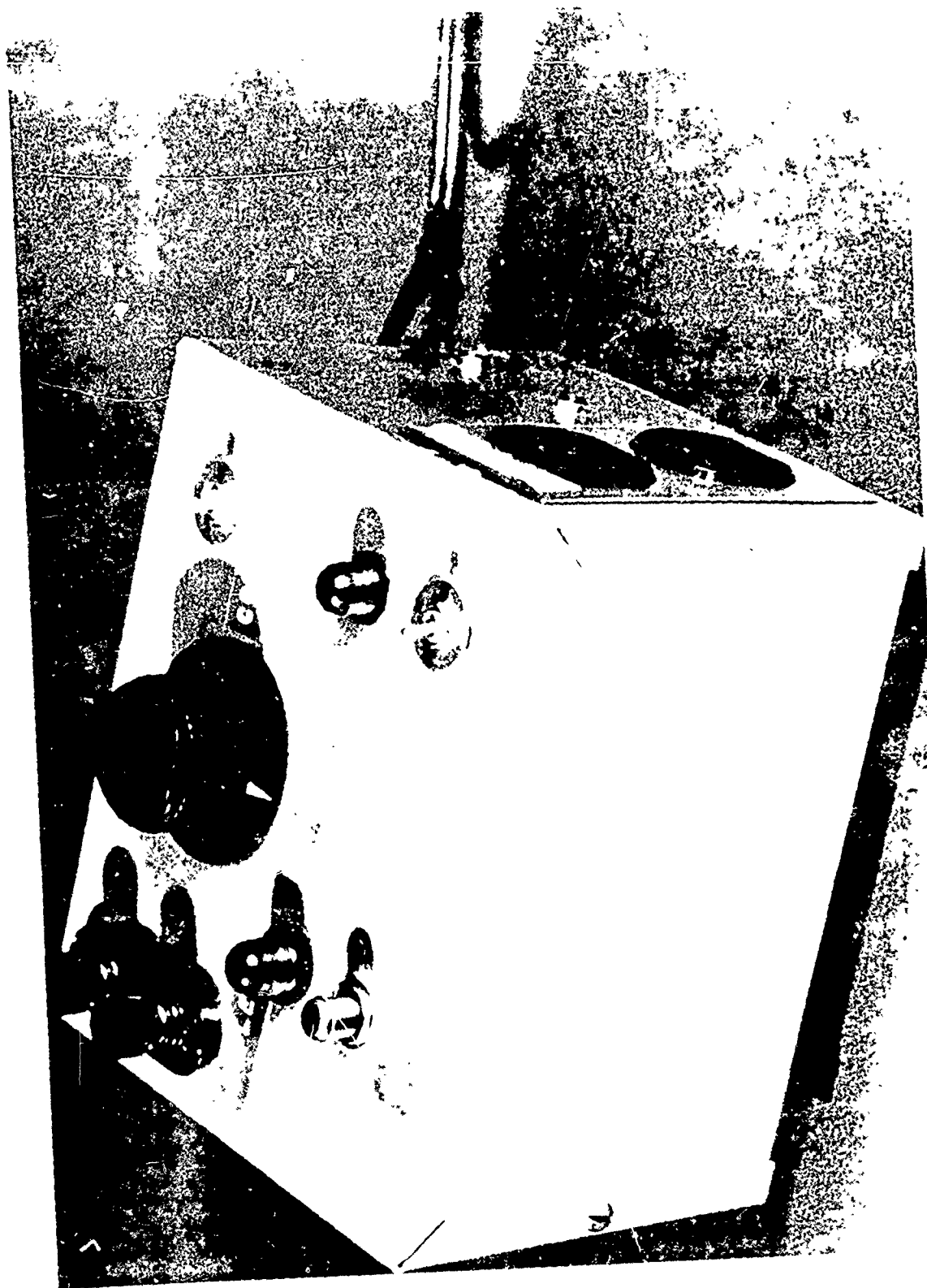
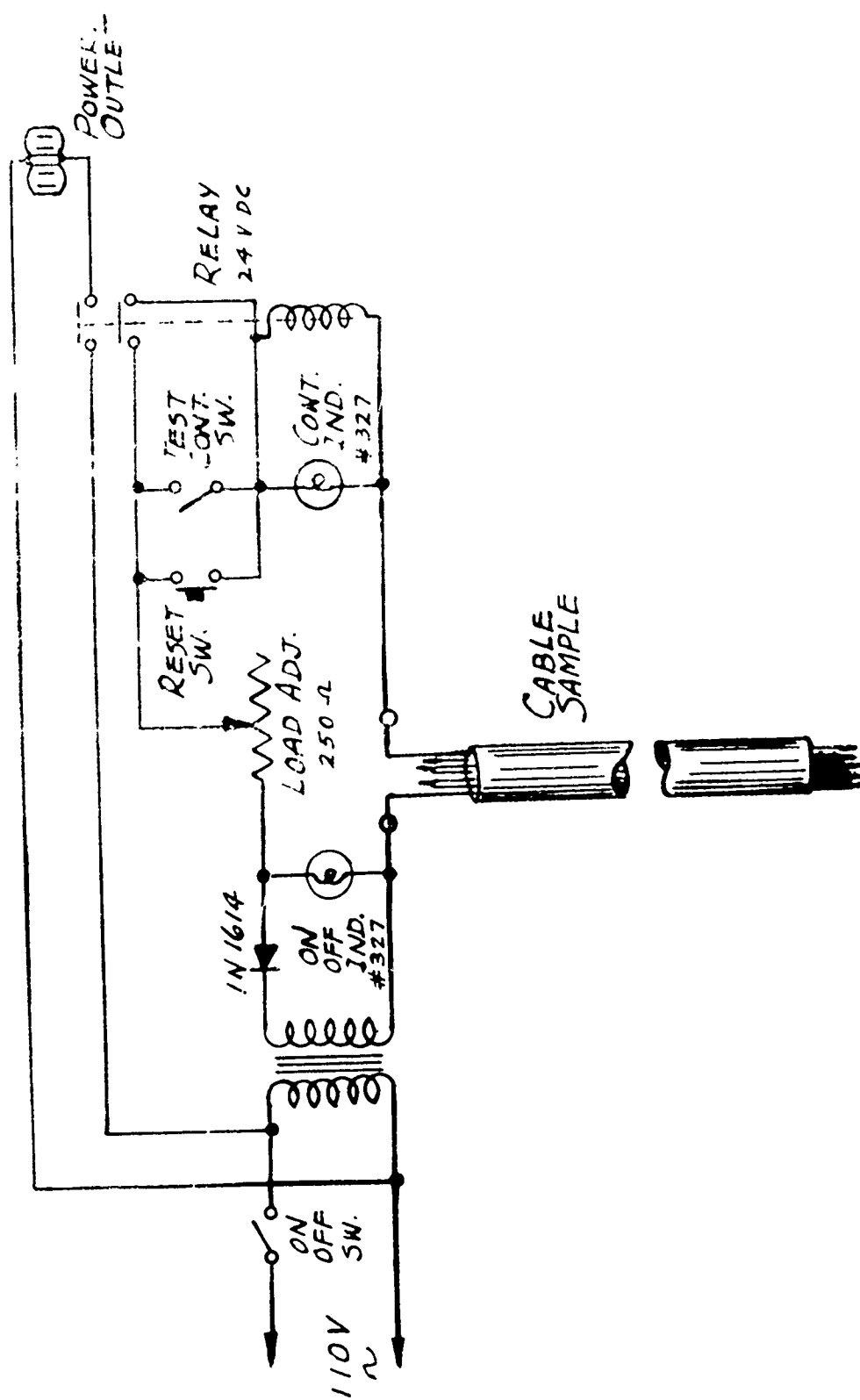


Figure 1
Discontinuity Automatic Control
9



Schematic - Discontinuity Automatic Control

Figure 2

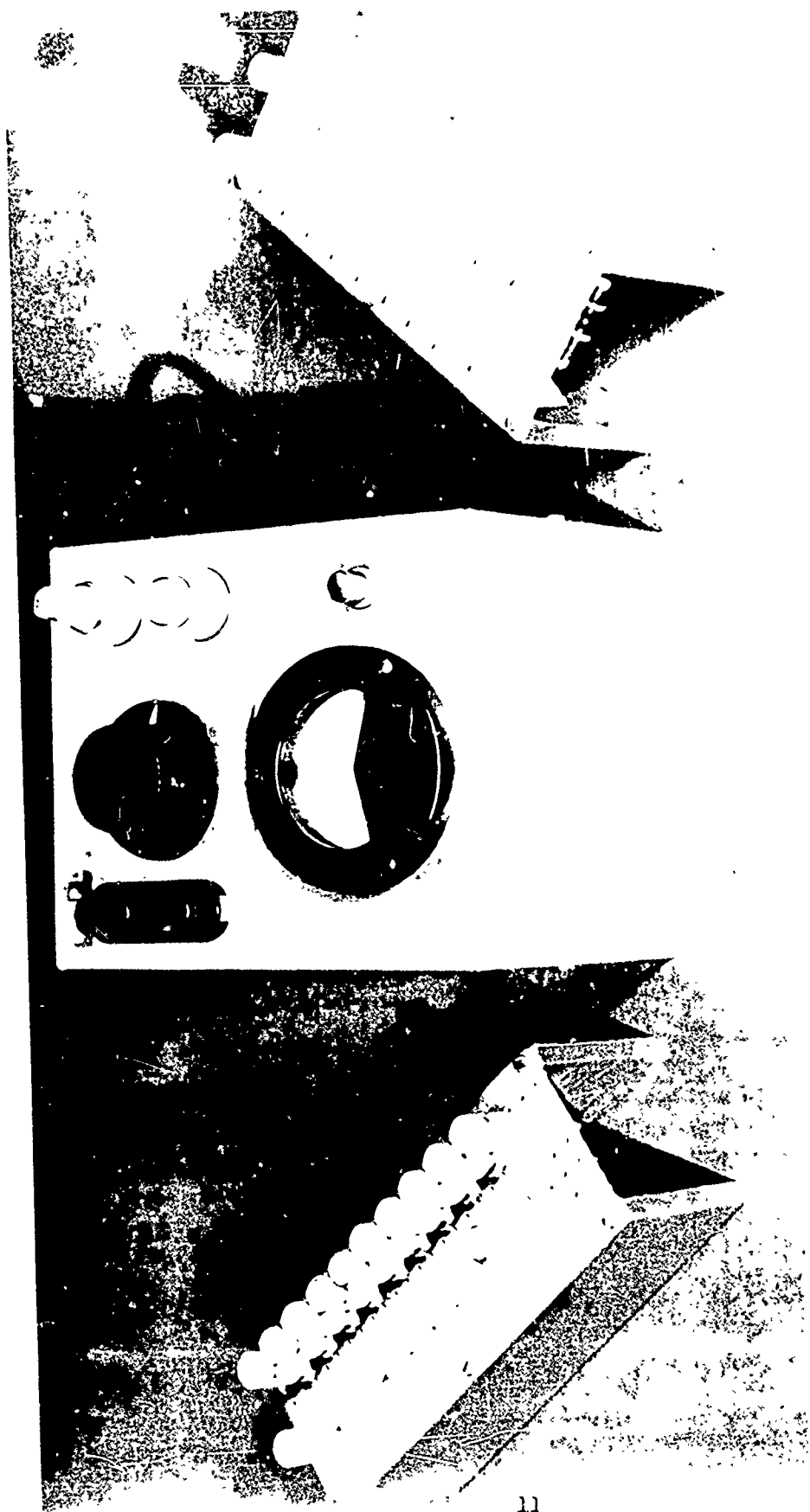


Fig. 3
Short-Open Indicator Box and Resistor Terminals

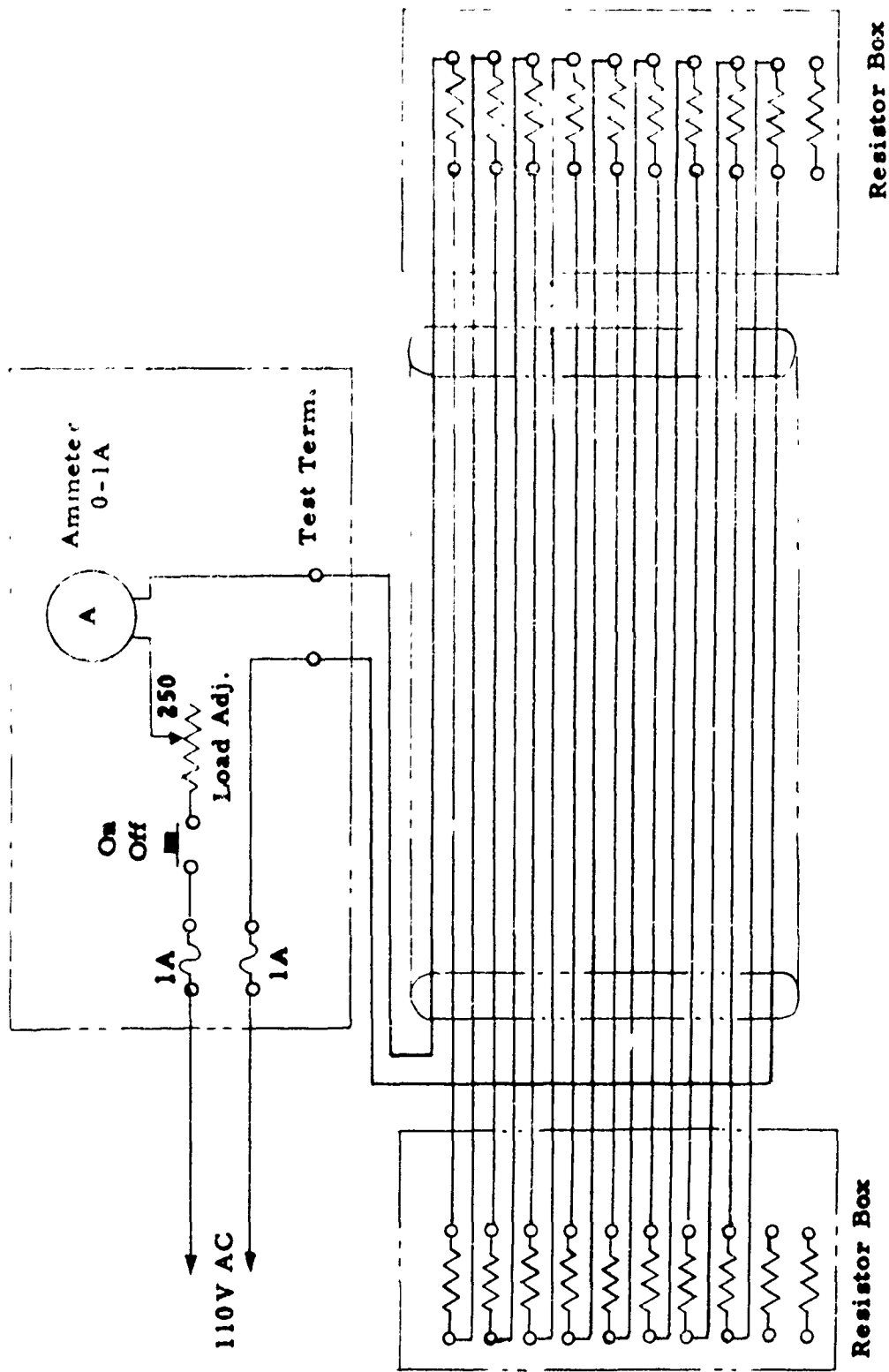
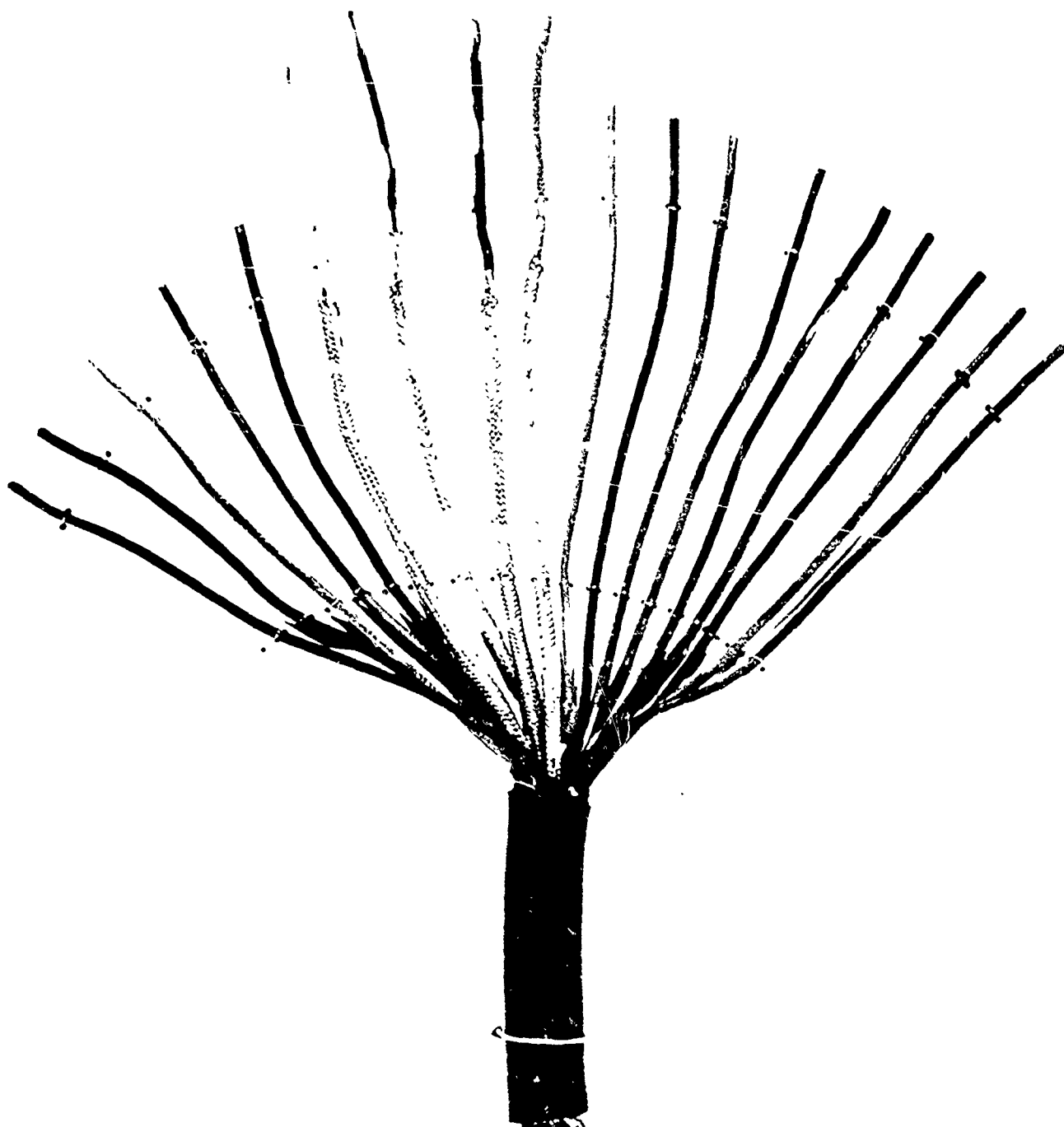


Fig. 4
Schematic - Short-Open Indicator

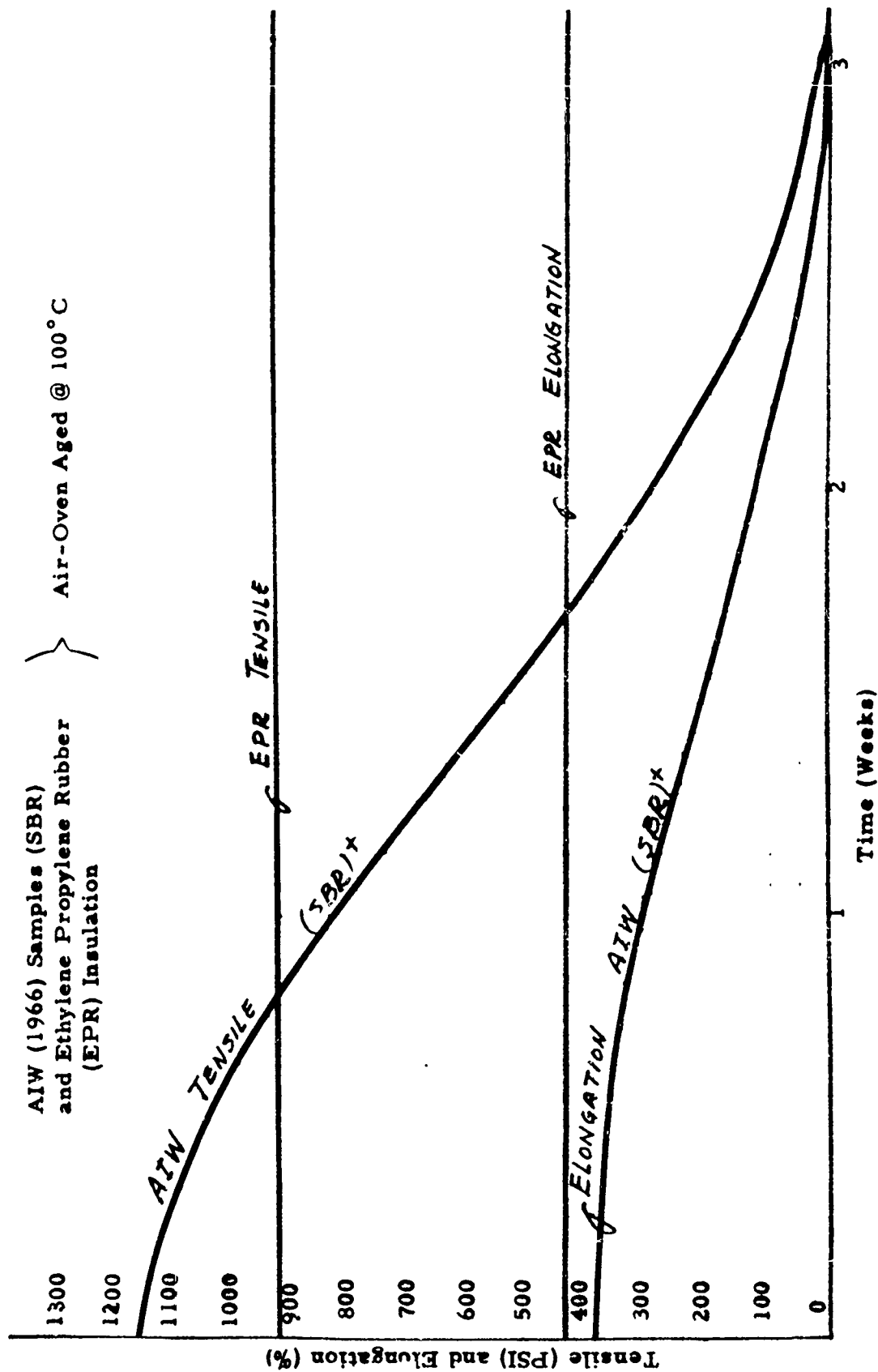


DEFECTIVE CABLE FROM
TOBYHANNA TYPE CO-18LOF
(14/22, 4/22 SI) 0500 PER
MIL-C-3432 AND SIMILAR TO
CABLE USED ON AN/VRC-12
EQUIPMENT



INSULATED CONDUCTORS
FROM DEFECTIVE CABLE

Fig. 6



* = Recent Tests
 + = (SBR) Styrene Butadiene Rubber
 *Tensile and Elongation (SBR & EPR Insulation)

Fig. 7

SUMMARY OF TESTS TABLE I

CABLE TYPE & MFR.		FLEX		IMPACT		TWTST		CONSTRUCTION	
No. of	FAULT	No. of	FAULT	No. of	FAULT	No. of	FAULT	No. of	FAULT
CYCLES	(CONC.)	CYCLES	(CONC.)	CYCLES	(CONC.)	CYCLES	(CONC.)	CYCLES	(CONC.)
CO-12 LOF (12/22) 19500 CYCLES (CONC.)									
1. CORNISH 1962	1429 0/2 (SM)	154	OK/2 (SM)	30/1	OK/2 (SM)	30/1	OK/2 (SM)	30/1	OK/2 (SM)
2. " " 1094	0/2 (SM)	149	OK/2 (SM)	30/1	OK/2 (SM)	30/1	OK/2 (SM)	30/1	OK/2 (SM)
3. " " 1649	0/2 (SM)	186	OK/2 (SM)	30/1	OK/2 (SM)	30/1	OK/2 (SM)	30/1	OK/2 (SM)
1. AMER. INS. WIRE 1964									
2. " " 2223	0/2 (SM)	17	OK/2 (SM)	19	OK/2 (SM)	19	OK/2 (SM)	19	OK/2 (SM)
3. " " 2176	0/2 (SM)	25	OK/2 (SM)	27	OK/2 (SM)	27	OK/2 (SM)	27	OK/2 (SM)
3. " " 1100	0/2 (SM)	25	OK/2 (SM)	27	OK/2 (SM)	27	OK/2 (SM)	27	OK/2 (SM)
1. AMER. INS. WIRE 1966									
2. " " 1647	0/2 (SM)	88	OK/2 (SM)	15,650	OK/2 (SM)	15,650	OK/2 (SM)	15,650	OK/2 (SM)
3. " " 1788	0/2 (SM)	7	OK/2 (SM)	20,319	OK/2 (SM)	20,319	OK/2 (SM)	20,319	OK/2 (SM)
3. " " 1312	0/2 (SM)	65	OK/2 (SM)	17,500	OK/2 (SM)	17,500	OK/2 (SM)	17,500	OK/2 (SM)
1. AMER. INS. WIRE 1963									
2. " " 518	0/2 (SM)	6	OK/2 (SM)	17,500	OK/2 (SM)	17,500	OK/2 (SM)	17,500	OK/2 (SM)
3. " " 329	0/2 (SM)	12	OK/2 (SM)	17,500	OK/2 (SM)	17,500	OK/2 (SM)	17,500	OK/2 (SM)
3. " " 556	0/2 (SM)	15	OK/2 (SM)	17,500	OK/2 (SM)	17,500	OK/2 (SM)	17,500	OK/2 (SM)
CO-12 LOF (12/22) 1925									
1. AMER. INS. W. 1965	9614 0/2 (SM)	15	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
2. " " 947	0/2 (SM)	20	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
3. " " 1245	0/2 (SM)	53	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
1. INDUSTRIAL CON. (A1M) 1965									
2. " " 153	0/2 (SM)	25	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
3. " " 1453	0/2 (SM)	25	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
3. " " 2029	0/2 (SM)	19	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
1. AMER. INS. WIRE 1965									
2. " " 196	0/2 (SM)	40	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
3. " " 1701	0/2 (SM)	20	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
3. " " 2030	0/2 (SM)	35	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
CO-12 LOF (12/22) 1925									
1. AMER. INS. WIRE 1965	56 0/2 (SM)	12	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
2. " " 173	0/2 (SM)	22	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
3. " " 323	0/2 (SM)	19	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
1. I.T.T. IMPROVEMENT 196									
2. " " 77	0/2 (SM)	9	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
3. " " 537	0/2 (SM)	12	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)
3. " " 500	0/2 (SM)	12	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)	10	OK/2 (SM)

1 2. HANDED. SEE TEST

TABLE 2 - TEST RESULTS

Tensile & Elongation of Copper Conductors

TENSILE		ELONGATION	
FORCE BREAK (LBS)	PSI	EXT'D LENGTH (IN.)	%
AIW 1964 COND. FROM 19 CYCLE TWIST TEST			
19.0	32700	4.25	6.25
17.5	30120	4.25	6.25
20.0	34440	4.31	7.7
17.25	29690	4.25	6.25
16.5	28399	x	x
19.5	33560	4.31	7.7
AIW 1964 COND. FROM 28 CYCLE TWIST TEST			
20.5	35280	4.25	6.25
17.0	29260	4.5	12.5
18.0	30980	4.25	6.25
19.0	32700	4.25	6.25
17.0	29260	4.5	12.5
16.5	28400	4.25	6.25
AIW 1963 LABELED "DRY-ROT" (LOT A)			
21.0	36140	4.25	6.25
20.5	35280	4.50	12.5
20.7	35628	4.375	9.4
20.0	34420	4.375	9.4
20.2	34760	4.25	6.25
20.5	35280	4.375	9.4
AIW 1963 LABELED "DRY-ROT" (LOT B)			
20.0	34420	4.375	9.4
20.5	35280	4.25	6.25
19.0	32700	4.25	6.25
18.5	31840	4.125	3.1
20.3	34390	4.375	9.4
21.3	36660	4.25	6.25
CORNISH			
17.0	29260	4.75	18.7
17.5	30120	4.75	18.7
17.0	29260	4.375	9.4
17.5	30120	x	x
17.0	29260	4.75	18.7

TEST RESULTS TABLE 3

TENSILE & ELONGATION

SAMPLE CABLE YEAR OF MFG COND. COLOR	UNAGED			AGED 168 HRS @ 100°C			AGED 2 WKS @ 100°C			AGED 5 WKS @ 100°C			AGED 12 WKS @ 100°C			AGED 24 WKS @ 100°C			AGED 48 WKS @ 100°C			AGED 96 WKS @ 100°C			AGED 192 WKS @ 100°C			AGED 384 WKS @ 100°C			AGED 768 WKS @ 100°C			AGED 1536 WKS @ 100°C			AGED 3072 WKS @ 100°C			AGED 6144 WKS @ 100°C			AGED 12288 WKS @ 100°C			AGED 24576 WKS @ 100°C			AGED 49152 WKS @ 100°C			AGED 98304 WKS @ 100°C			AGED 196608 WKS @ 100°C			AGED 393216 WKS @ 100°C			AGED 786432 WKS @ 100°C			AGED 1572864 WKS @ 100°C			AGED 3145728 WKS @ 100°C			AGED 6291456 WKS @ 100°C			AGED 12582912 WKS @ 100°C			AGED 25165824 WKS @ 100°C			AGED 50331648 WKS @ 100°C			AGED 100663296 WKS @ 100°C			AGED 201326592 WKS @ 100°C			AGED 402653184 WKS @ 100°C			AGED 805306368 WKS @ 100°C			AGED 1610612736 WKS @ 100°C			AGED 3221225472 WKS @ 100°C			AGED 6442450944 WKS @ 100°C			AGED 12884901888 WKS @ 100°C			AGED 25769803776 WKS @ 100°C			AGED 51539607552 WKS @ 100°C			AGED 103079215104 WKS @ 100°C			AGED 206158430208 WKS @ 100°C			AGED 412316860416 WKS @ 100°C			AGED 824633720832 WKS @ 100°C			AGED 1649267441664 WKS @ 100°C			AGED 3298534883328 WKS @ 100°C			AGED 6597069766656 WKS @ 100°C			AGED 13194139533312 WKS @ 100°C			AGED 26388279066624 WKS @ 100°C			AGED 52776558133248 WKS @ 100°C			AGED 105553116266496 WKS @ 100°C			AGED 211106232532992 WKS @ 100°C			AGED 422212465065984 WKS @ 100°C			AGED 844424930131968 WKS @ 100°C			AGED 1688849860263936 WKS @ 100°C			AGED 3377699720527872 WKS @ 100°C			AGED 6755399441055744 WKS @ 100°C			AGED 13510798882111488 WKS @ 100°C			AGED 27021597764222976 WKS @ 100°C			AGED 54043195528445952 WKS @ 100°C			AGED 108086391056891904 WKS @ 100°C			AGED 216172782113783808 WKS @ 100°C			AGED 432345564227567616 WKS @ 100°C			AGED 864691128455135232 WKS @ 100°C			AGED 1729382256910270464 WKS @ 100°C			AGED 3458764513820540928 WKS @ 100°C			AGED 6917529027641081856 WKS @ 100°C			AGED 13835058055282163712 WKS @ 100°C			AGED 27670116110564327424 WKS @ 100°C			AGED 55340232221128654848 WKS @ 100°C			AGED 110680464442257309696 WKS @ 100°C			AGED 221360928884514619392 WKS @ 100°C			AGED 442721857769029238784 WKS @ 100°C			AGED 885443715538058477568 WKS @ 100°C			AGED 1770887431076116955136 WKS @ 100°C			AGED 3541774862152233910272 WKS @ 100°C			AGED 7083549724304467820544 WKS @ 100°C			AGED 14167099448608935641088 WKS @ 100°C			AGED 28334198897217871282176 WKS @ 100°C			AGED 56668397794435742564352 WKS @ 100°C			AGED 113336795588871485128704 WKS @ 100°C			AGED 226673591177742970257408 WKS @ 100°C			AGED 453347182355485940514816 WKS @ 100°C			AGED 906694364710971881029632 WKS @ 100°C			AGED 1813388729421943762059264 WKS @ 100°C			AGED 3626777458843887524118528 WKS @ 100°C			AGED 7253554917687775048237056 WKS @ 100°C			AGED 14507109835375550096474112 WKS @ 100°C			AGED 29014219670751100192948224 WKS @ 100°C			AGED 58028439341502200385896448 WKS @ 100°C			AGED 116056878683004400771792896 WKS @ 100°C			AGED 232113757366008801543585792 WKS @ 100°C			AGED 464227514732017603087171584 WKS @ 100°C			AGED 928455029464035206174343168 WKS @ 100°C			AGED 1856910058928070412388686336 WKS @ 100°C			AGED 3713820117856140824777372672 WKS @ 100°C			AGED 7427640235712281649554745344 WKS @ 100°C			AGED 1485528047142456329910949068 WKS @ 100°C			AGED 29710560942849126598218981376 WKS @ 100°C			AGED 59421121885698253196437962752 WKS @ 100°C			AGED 118842243771396506392875925504 WKS @ 100°C			AGED 237684487542793012785751851008 WKS @ 100°C			AGED 475368975085586025571503702016 WKS @ 100°C			AGED 950737950171172051143007404032 WKS @ 100°C			AGED 1901475900342344102286014808064 WKS @ 100°C			AGED 3802951800684688204572029616128 WKS @ 100°C			AGED 7605903601369376409144059232256 WKS @ 100°C			AGED 15211807202738752818288118464512 WKS @ 100°C			AGED 30423614405477505636576236929024 WKS @ 100°C			AGED 60847228810955011273152473858048 WKS @ 100°C			AGED 121694457621910022546304947716096 WKS @ 100°C			AGED 243388915243820045092609895432192 WKS @ 100°C			AGED 486777830487640090185219790864384 WKS @ 100°C			AGED 973555660975280180370439581728768 WKS @ 100°C			AGED 1947111321950560360740879163457536 WKS @ 100°C			AGED 3894222643901120721481758326915072 WKS @ 100°C			AGED 7788445287802241442963516653830144 WKS @ 100°C			AGED 15576890575604482885927033307660288 WKS @ 100°C			AGED 31153781151208965771854066615320576 WKS @ 100°C			AGED 62307562302417931543708133230641152 WKS @ 100°C			AGED 124615124604835863087416266461282304 WKS @ 100°C			AGED 249230249209671726174832532922564608 WKS @ 100°C			AGED 498460498419343452349665065845129216 WKS @ 100°C			AGED 996920996838686904699330131690258432 WKS @ 100°C			AGED 1993841993677373809398660263380516864 WKS @ 100°C			AGED 3987683987354747618797320526761033728 WKS @ 100°C			AGED 7975367974709495237594641053522067456 WKS @ 100°C			AGED 15950735949418990475189282107044134912 WKS @ 100°C			AGED 31901471898837980950378564214088269824 WKS @ 100°C			AGED 63802943797675961900757128428176539648 WKS @ 100°C			AGED 127605887595351923801514256856353079296 WKS @ 100°C			AGED 255211775190703847603028513712706158592 WKS @ 100°C			AGED 510423550381407695206057027425412317184 WKS @ 100°C			AGED 1020847100762815390412114054850824643776 WKS @ 100°C			AGED 2041694201525630780824228109701649287552 WKS @ 100°C			AGED 4083388403051261561648456219403298575104 WKS @ 100°C			AGED 8166776806102523123296912438806597150208 WKS @ 100°C			AGED 16333553612205046246593824877613194300416 WKS @ 100°C			AGED 32667107224410092493187649755226388600832 WKS @ 100°C			AGED 65334214448820184986375299510452777201664 WKS @ 100°C			AGED 1306684288976403699727505990209055444032 WKS @ 100°C			AGED 261336857795280739945501198041811088864 WKS @ 100°C			AGED 5226737155905614798910023960836221777728 WKS @ 100°C			AGED 10453474311811229597820047921672443554456 WKS @ 100°C			AGED 20906948623622459195640095843344887108912 WKS @ 100°C			AGED 41813897247244918391280191686689772178224 WKS @ 100°C			AGED 83627794494489836782560383373379544356448 WKS @ 100°C			AGED 1672555889889796735651207667467590887128896 WKS @ 100°C			AGED 334511177977959347130241533493518177457792 WKS @ 100°C			AGED 6690223559559186942604830669870363549155584 WKS @ 100°C			AGED 13380447119118373885209661339740727098311168 WKS @ 100°C			AGED 26760894238236747770419322679481454196622336 WKS @ 100°C			AGED 53521788476473495540838645358962908393244672 WKS @ 100°C			AGED 107043576952946991081677290717925816786489344 WKS @ 100°C			AGED 214087153905893982163354581435851633572978688 WKS @ 100°C			AGED 428174307811787964326709162871703267145973776 WKS @ 100°C			AGED 856348615623575928653418325743406534291947552 WKS @ 100°C			AGED 171269723124715185730683665148681306558389504 WKS @ 100°C			AGED 342539446249430371461367330297362613116779008 WKS @ 100°C			AGED 685078892498860742922734660594725226233578016 WKS @ 100°C			AGED 1370157784997721485845469321189450452467156032 WKS @ 100°C			AGED 2740315569995442971690938642378900904934312064 WKS @ 100°C			AGED 5480631139990885943381877284757801809868624128 WKS @ 100°C			AGED 10961262279981771886763754569515603619737248256 WKS @ 100°C			AGED 21922524559963543773527509139031207239474496512 WKS @ 100°C			AGED 43845049119927087547055018278062414478948993024 WKS @ 100°C			AGED 87690098239854175094110036556124828957897986048 WKS @ 100°C			AGED 175380196479708350188220073112249657915795972096 WKS @ 100°C			AGED 350760392959416700376440146224499315831591944192 WKS @ 100°C			AGED 701520785918833400752880292448998631663183888384 WKS @ 100°C			AGED 1403041571837666801505760584897997263326367776768 WKS @ 100°C			AGED 2806083143675333260139261027750057939342269606882423808 WKS @ 100°C			AGED 5612166287350667206023042339591989053305471107072 WKS @ 100°C			AGED 11224332574701334412046084679183978106610922140144 WKS @ 100°C			AGED 22448665149402668824092169358367956213221844280288 WKS @ 100°C			AGED 44897330298805337648184338716735912426443688560576 WKS @ 100°C			AGED 89794660597610675296368677433471824852887377121152 WKS @ 100°C			AGED 179589321195221350592737354866943649705774754242304 WKS @ 100°C			AGED 359178642390442701185474709733887299411549508484608 WKS @ 100°C			AGED 718357284780885402370949419467774598823099016969216 WKS @ 100°C			AGED 1436714569561770804741898838935549197646198033938432 WKS @ 100°C			AGED 2873429139123541609483797677871098395292396067876864 WKS @ 100°C			AGED 5746858278247083218967595355742196790584792135753728 WKS @ 100°C			AGED 11493716556494166437935190711484393581169584271507456 WKS @ 100°C			AGED 229874331129883328758703814229687871623391685430151488 WKS @ 100°C			AGED 459748662259766657517407628459375743246783700860302976 WKS @ 100°C			AGED 919497324519533315034815256918751484835567401720605952 WKS @ 100°C			AGED 1838994649039066630069630513875028969671134803441211904 WKS @ 100°C			AGED 3677989298078133260139261027750057939342269606882423808 WKS @ 100°C			AGED 7355978596156266520278522055500115878884538013764447616 WKS @ 100°C			AGED 14711957192312533040557044111000237755555817525477778464 WKS @ 100°C			AGED 2942391438462506608111408822200047555555817525477778464 WKS @ 100°C			AGED 5884782876925013216222817644400095111111630050955556928 WKS @ 100°C			AGED 1176956575385002643244563528880019022222326010191113856 WKS @ 100°C			AGED 23539131507700052864891270577600380444446520203822227712 WKS @ 100°C			AGED 47078263015400105729782541155200760888893040407644444444 WKS @ 100°C			AGED 941565260308002114595650823104015217777860808152888888888 WKS @ 100°C			AGED 1883130520616004291911301646208030435557216161528888888888 WKS @ 100°C			AGED 3766261041232008583822603292416060871114423223057777777777 WKS @ 100°C			AGED 75325220824640171676452065848321 WKS @ 100°C		
	COND. COLOR	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB	PSI	IN.	ELONGATION	%	LB</																																																																																																																		

TABLE 4
Repetition Rate of Conductor Failures for all Cable Samples
Flex, Impact & Twist Tested

CABLE TYPE: CO-18LOF(14/22 - 4/22 SI) 0500

Conductor (Color)

TESTS	NUMBER OF FAILURES	Conductor (Color)													
		3	R	G	BK	BLU	O	W/BK	G/W	R/W	BLU/W (SH)	BK/R (SH)	W/R (SH)	O/R (SH)	R/BK
FLEX	1	✓	✓				✓	✓	✓		✓	✓	✓	✓	
	2	✓								✓		✓	✓		
	3														✓
IMPACT	1		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
	2					✓	✓	✓				✓	✓		✓
	3					✓		✓							✓
	4														✓
TWIST	1		✓	✓				✓	✓	✓		✓		✓	✓
	2								✓					✓	✓

CABLE TYPE: CO-12LOF(12/22) 0325

FLEX	1		✓		✓	✓	✓	x	x	x	x	x	x		✓	✓	✓
	2		✓		✓		✓								✓	✓	
	3		✓												✓		
	4		✓														
	5																
IMPACT	1		✓	✓	✓	✓	✓	x	x	x	x	x	x	✓	✓	✓	✓
	2		✓		✓		✓							✓	✓	✓	✓
	3		✓		✓											✓	✓
	4		✓														
TWIST		Discontinued test @ high life cycle. Also insufficient samples.															

CABLE TYPE: CO-09LOF(7/22 - 2/22 SI) 0325

FLEX	1	✓	✓	✓		✓	x	x	x		x	x	SH	✓	x	x	x
	2		✓										✓				
	3		✓														
IMPACT	1	✓	✓	✓	✓	✓	✓	x	x	x		x	x	x	x	x	x
	2	✓	✓	✓		✓	✓	✓									
	3	✓	✓			✓											
	4	✓															
	5	✓															
TWIST	1	✓	✓	✓	✓	✓	✓	x	x	x		x	x	x	SH	x	x
	2		✓		✓	✓											
	3				✓												
	4				✓												
	5				✓												

X = no conductor of corresponding color

✓ = Failure

APPENDIX

ABBREVIATIONS

Cond	Conductor
Ins	Insulation
Str	Strand(s)
Text	Textile
T C	Tinned Copper
SBR	Styrene Butadiene Rubber
Sh, Sh'd	Shield(s)(ed)
AIW	American Insulated Wire Company
Bk/W	Black solid color with White tracer
G/W	Green " " " " "
R/W	Red " " " " "
Blu/W	Blue " " " " "
Bk/R	Black " " " Red "
W/R	White " " " " "
O/R	Orange " " " " "
R/Bk	Red " " " Black "
G/Bk	Green " " " " "
O/Bk	Orange " " " " "
Blu/Bk	Blue " " " " "
W/Bk	White " " " " "
W	White solid color
R	Red " "
G	Green " "
Bk	Black " "
Blu	Blue " "
O	Orange " "

TABLE A1
TEST RESULTS

Cable Type: CO-18LOF (14/22, 4/22 SI) 0500

Manufacturer: Cornish Wire

Date of Mfr: 1962

*Description of Cable:

Received From: Components & Materials Division, Coles Area

Wrap: Cotton

Jacket: Polychloroprene

Conductors: 14 Cond. #22 AWG, consisting of 16 Str. #34 AWG (.0063")
Tin. Copper

4 Cond. #22 AWG, Shielded cond. 16/#34 AWG Shielded

Braid consisting of 65 Str. .005 ± in. T C

Insulation: SBR with Textile Braid

FLEX TESTS

Cable Sample No.	No. of Cycles	Fault (Conductor)	*Remarks
1	1094	O/R (Sh'ld)	Cond. broken; ins=OK; Text. braid=OK; Approx 50% of Sh. Str. broken
2	1429	O/R (Sh'ld)	Same as above
3	1649	Bk/R (Sh'ld)	Same as above

IMPACT TESTS 15# Hammer Weight 6" Hammer Drop

1	149		Short only on impact; exam. did not reveal fault; Text. braid over ins. frayed; ins=OK; Almost all of sh. broken indicating possibly that short was due to sh'ld str. being driven into ins. to cond.
2	167 to 186	G/Bk	First indication of short @167~. To definitely locate fault, test was continued to 186~. Exam. showed ins. frayed to bare cond. but not shorting due to good ins. of adjacent R/Bk, R, G & O/Bk cond.
		O	Braid frayed; ins. broken; no short due to good ins. on adjacent cond. (Bk & R/W).
		R, G/W, R/W, Bk, W	Braid frayed; ins=OK
		O/R (Sh'ld)	All sh'ld str. broken; possibly sh'ld str. penetrated thru ins. or to adjacent Blu/W (Sh) cond. or below to O/R(Sh) and directly below blow of impact hammer.
		W/R (Sh)	Same as above O/R (sh)
		Bk/R (Sh)	Same except this cond. is on the outside of O/R (Sh) and adjacent to Blu/W (Sh)
		Blu/W (Sh)	Same except this cond. was on the bottom (next to anvil) & was exposed to broken sh'ld str. of all the other sh'ld cond.

Table A1 (continued)

Cable Sample No.	No. of Cycles	Fault (Conductor)	*Remarks
3	154	Bk/R (Sh) G/W, Bk/W R/Bk, O, Bk W/Bk, W, W/R (Sh), O/R (Sh)	Cond. broken; all sh'ld str. broken; text. braid frayed; Bk/W, G/W, R/W, Blu/W (Sh) Cond. are on the bottom. Text. braid frayed thru; cond=OK; ins=OK
TWIST TESTS		40# Weight	
1	3698	W/R (Sh)	Cond. broken; few sh'ld str. broken
2		(No more cable)	

*See List of Abbreviations

TABLE A2
TEST RESULTS

Cable Type: CO-18LOF (14/22, 4/22 SI) 0500

Description of Cable:

Conductors: 14 cond. #22 AWG, consisting of 16 str. #34 AWG (.0063") T C
4 cond. #22 AWG, sh'ld cond. 16/#34 AWG sh'ld braid consisting of 65/.005± in. T C (Mylar tape under sh)

Insulation: SBR

Binder and Wrap: Cotton

Jacket: Polychloroprene

(1) Manufacturer: American Ins. Wire (AIW)

Date of Mfr: 1964

Received from: Components & Materials Division, Coles Area

Cable Sample No.	No. of Cycles	Fault (Conductors)	Remarks
FLEX TESTS			
1	2976	W/R (Sh) Bk/W	Cond. broken; ins=OK; few sh. str. broken
2	3101	Bk/W, R/W, W/R (Sh) Shields	Same as above Approx. 50% of str. broken
3	2223	R/Bk	Cond. broken; ins=OK
4	1100	Bk/W Shields	Same as above Few str. broken
IMPACT TESTS 15# Hammer Weight 6" Hammer Drop			
1	20	W/Bk, G/Bk R/Bk R/W	Cond. broken; ins=OK Cond. broken; ins. split
2	25	Bk/W, Blu/Bk O, G, Blu Bk/W W/R (sh), W/Bk Shields	Pinhole in ins; probably from sh. str. Cond. broken; ins=OK Same as above Almost all str. broken
3	17	Blu/Bk, O Shields	Cond. broken; ins=OK Few str. broken
TWIST TESTS 40# Weight			
1	19	Bk/W, Blu/Bk, O/Bk G/W, G, R	Cond. broken; ins=OK Same as above
2	28	O/Bk, G/W R/W Shields	Same as above OK

Table A2 (continued)

(2) Manufacturer American Ins. Wire (AIW) Date of Mfr: 1963
Cables Labeled Dry-Rot" (see text)
Received from: Tobyhanna Military Depot

Cable Sample No.	No. of Cycles	Fault (Conductors)	Remarks
FLEX TESTS			
1	588	G/W	Cond. broken, ins, etc. Ok
2	329	W	Same as above
3	556	R	Same as above
IMPACT TESTS 15# Hammer Weight 6" Hammer Drop			
1	6	-	Failure not visible, probably short to sh.
2	12	Blu, Bk/W	Short. Ins. cut thru exposing cond. to sh.
3	15	W/Bk, Bk	Same as above
TWIST TESTS 40# Weight			
1	8027	R/Bk, G/Bk	Cond. broken, ins OK; sh. str. almost all broken at several places
No More Cable			

(3) Manufacturer: American Ins. Wire (AIW) Date of Mfr: 1966
Wrap: Mylar Tape
Received from: Manufacturer

FLEX TESTS			
1	1647	W	Cond. broken; ins, sh, wrap = OK
2	1788	R/W	Same as above
3	1312	O	Cond. broken; ins. OK; some sh. str. broken
IMPACT TESTS 15# Hammer Weight 6" Hammer Drop			
1	88	G/Bk, O/Bk, Bk/W	Cond. broken; ins-OK; Mylar wrap broken; all sh. str. broken
2	71	R	Ins. cut thru and shorted to adjacent shield of frayed "O/R" cond.
3	65	Blu	cond. broken; ins - OK
TWIST TESTS 40# Weight			
1	15,650	W/Bk, R/Bk(Sh)	Cond. broken; Mylar wrap broken; ins. worn thru and cond. exposed; approx. 50% of sh. str. broken
2	20,379		No Failures
3	17,540		No Failures

TABLE A3
TEST RESULTS

Cable Type: CO-12LOF (12/22) 0325

Description of Cable:

Conductors: 12 #AWG; Each cond. consisting of 16/#34 AWG (.0063") TC

Insulation: SBR

Binder: Cotton

Wrap: Mylar Tape

Jacket: Polychloroprene

(1) Manufacturer: American Ins. Wire (AIW) Date of Mfr: 1965

Received from: Manufacturer

Cable Sample No.	No. of Cycles	Fault (Conductor)	Remarks
FLEX TESTS			
1	986	W/Bk	Cond. broken; ins=OK; Mylar wrap broken
2	1701	O/Bk	Same as above
3	2066	G, O	Same as above
IMPACT TESTS 15# Weight 2" Hammer Drop			
1	46	G/Bk, R/Bk	Cond. broken; ins=OK
2	26	O/Bk	Same as above
3	35	-	No Failure
TWIST TESTS 40# Weight			
1	23,066	-	No Failure
2	18,500	-	No Failure
3	15,000	-	No Failure

(2) Manufacturer: American Ins. Wire (AIW) Date of Mfr: 1965

Wrap: Cotton

Received from: Components & Materials Division, Coles Area

FLEX TESTS			
1	3614	G, G/Bk	Cond. broken; ins=OK
2	947	Blu, G/Bk	Same as above
		O/Bk	
3	1245	G	Same as above
IMPACT TESTS 15# Hammer Weight 2" Hammer Drop (2)			
1	53	O, Blu	Cond. broken; ins=OK
2	26	Bk/W, Blu/Bk	Same as above
3	15	G	Same as above
TWIST TESTS			
No More Cable			

Table A3 (Continued)

(3) Manufacturer: Industrial Components Co.
(Actually AIW)

Date of Mfr: June 1965

Received from: Tobyhanna Military Depot

Cable Sample No.	No. of Cycles	Fault (Conductors)	Remarks
FLEX TESTS			
1	853	Blu	Cond. broken; ins, etc. = OK
2	1653	Bk/W, G/Bk	Same as above
3	1653	G/W, Bk	Same as above
IMPACT TESTS 15# Hammer Weight 3" Hammer Drop (1)			
1	2	Blu/Bk, W/Bk, G	Cond. broken; ins, etc. = OK
2	3	Bk/W, G	Same as above
3	6	Bk, Blu/Bk W/Bk	Same as above
IMPACT TESTS 15# Hammer Weight 2" Hammer Drop (2)			
1	21	Blu, G/Bk	Cond. broken; ins, etc. = OK
2	25	Bk/W, Blu	Same as above
3	19	R/Bk, G	Same as above
TWIST TESTS 40# Weight			
1	13,890	NF (3)	Mylar tape frayed thru
2	14,960	NF	Same as above
3	13,600	NF	Same as above

NOTE:

- (1) 3" Hammer drop too severe for this light-duty, small dia. cable
- (2) Hammer drop reduced to 2" drop
- (3) NF = No Failure

TABLE A4
TEST RESULTS

Cable Type: CO-09LOF (7/22, 2/22 SI) 0325

Description of Cable:

Conductors: 7 Cond. #22 AWG, consisting of 16 Str./#34 AWG (.0063") TC
2 Cond. #22 AWG, sh'ld cond. 16/#34 AWG sh'ld braid consist-
ing of 65/.005± in. TC (Mylar tape under sh)

Insulation: SBR

Binder: Cotton

Wrap: Mylar Tape

Jacket: Polychloroprene

(1) **Manufacturer:** American Insulated Wire (AIW) **Date of Mfr:** 1965
Received from: Tobyhanna Army Depot

Cable Sample No.	No. of Cycles	Fault (Conductors)	Remarks
FLEX TESTS			
1	86	R	Cond. broken; ins. - OK
2	179	Bk/R (Sh), G/Bk	Same as above
3	303	Bk/R (Sh) Shields	Same as above Few strands broken
IMPACT TESTS 15# Hammer Weight 2" Hammer Drop			
1	12	R, W, Bk, W/Bk, Blu, O, G Shields	Cond. broken; ins. - OK All str. broken; Mylar wrap broken
2	22	R, G, W Shields	Cond. broken; ins. - OK All str. broken; Mylar wrap broken
3	19	R, O, W/Bk Shields	Cond. broken; ins. - OK All str. broken; Mylar wrap broken
TWIST TESTS 40# Weight			
1	5243	Bk	Cond. broken; ins. - OK; some sh. str. broken
2	3201	Bk	Same as above
3	5821	-	

Manufacturer: ITT Surprenant

Date of Mfr: 1966

Wrap: Textile Reinforced Polychloroprene Jacket

Received from: Manufacturer

FLEX TESTS			
1	77	R	Cond. broken; ins., etc. OK
2	509	R, W, G	Same as above
3	500	O	Same as above

Table A4 (continued)

Cable Sample No.	No. of Cycles	Fault (Conductors)	Remarks
IMPACT TESTS		15# Hammer	2" Hammer Drop
1	98	W, Blu	Cond.ins.broken & cond.exposed & shorted to
2	112	W, Blu	sh; sh.str.all broken; cond.under sh.protected
3	94	W	from shorting to sh.by Mylar wrap
TWIST TESTS		40# Weight	
1	6156	W, R, G, O, Blu Bk	Cond.broken; ins. - OK; sh.str.all broken
2	4167	R, Blu, Bk W/ Bk	Same as above
3	5008	Bk, G/ Bk(Sh)	Same as above

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13. ABSTRACT <p>This study was initiated to investigate the cause of various reports of field failures of wires and cables (multi-conductor), specifically cables which are part of the AN/VRC-12 Radio Equipment.</p> <p>Various types of cables, fabricated per MIL-C-3432 and similar to those reported as having failed in tactical use, were tested.</p> <p>A description of each type is provided in this report along with detailed physical test data, such as tensile and elongation of conductor insulating material (aged and unaged) and mechanical tests on the cable such as, flex, impact and twist.</p> <p>None of the cables tested exhibited outstanding performance in all the mechanical tests. When cables did perform very well with regard to one or two tests, they did poorly in others. All cables exhibited variations of performance and practically no correlation was obtained between the mechanical tests and the physical characteristics of the insulation.</p> <p>Performance tests, however, do offer some control on the construction and manufacturing variables of the cable. New design considerations are recommended based upon the evaluation. Requirements for the physical properties of the insulation are also recommended to upgrade the material and provide greater stability with respect to accelerated temperature aging. Mechanical performance tests on</p>		

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Cable, multiconductor Cable, Extra flexible Cable, Electrical Cable, Light duty			
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finished cable are recommended to provide an overall control on the constructional quality of the finished cable.

These tests will be incorporated in Military Specification MIL-C-3432 along with appropriate changes in Government inspection procedures to insure improved reliability of multi-conductor cables.